EE 420/ECG 620 Electronics II/Analog IC Design

Lecture 16

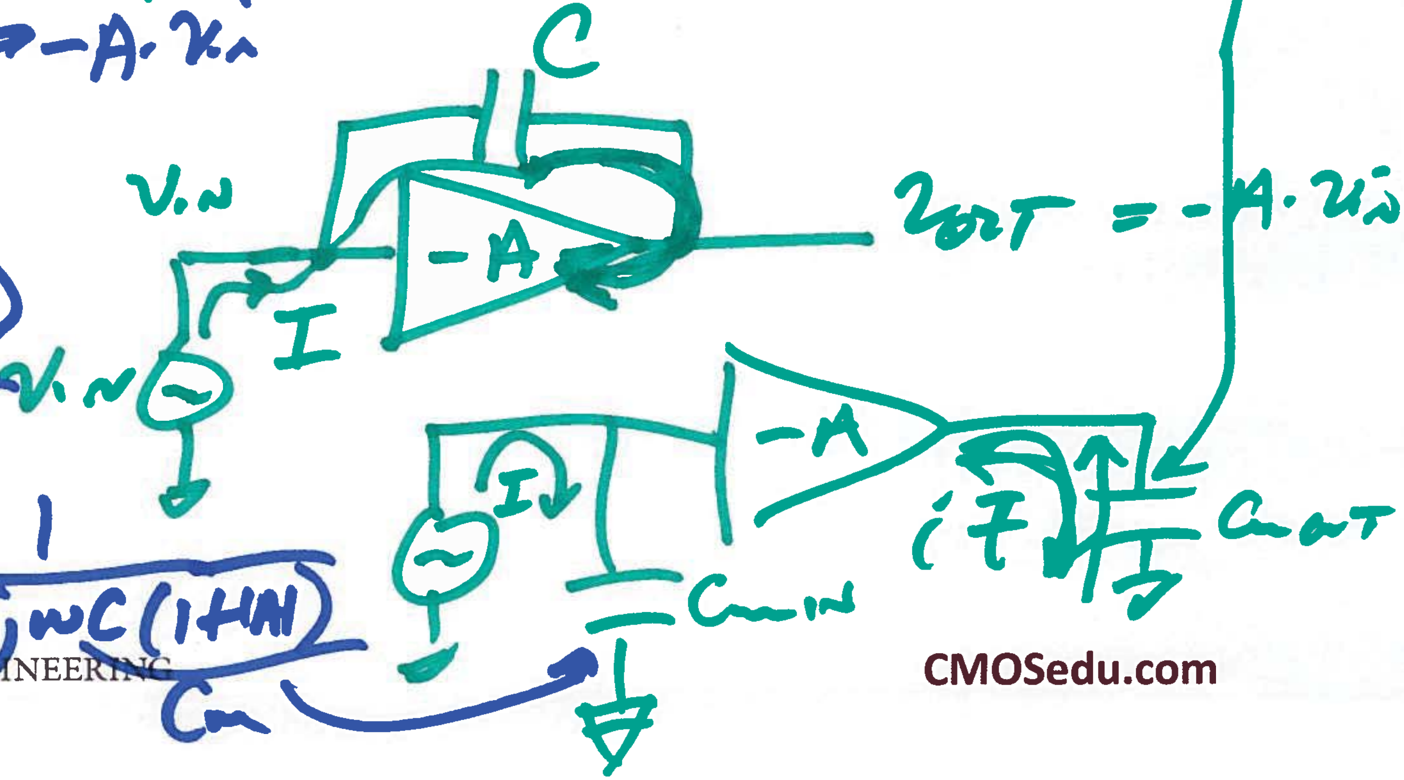
MARCH 20, 2017

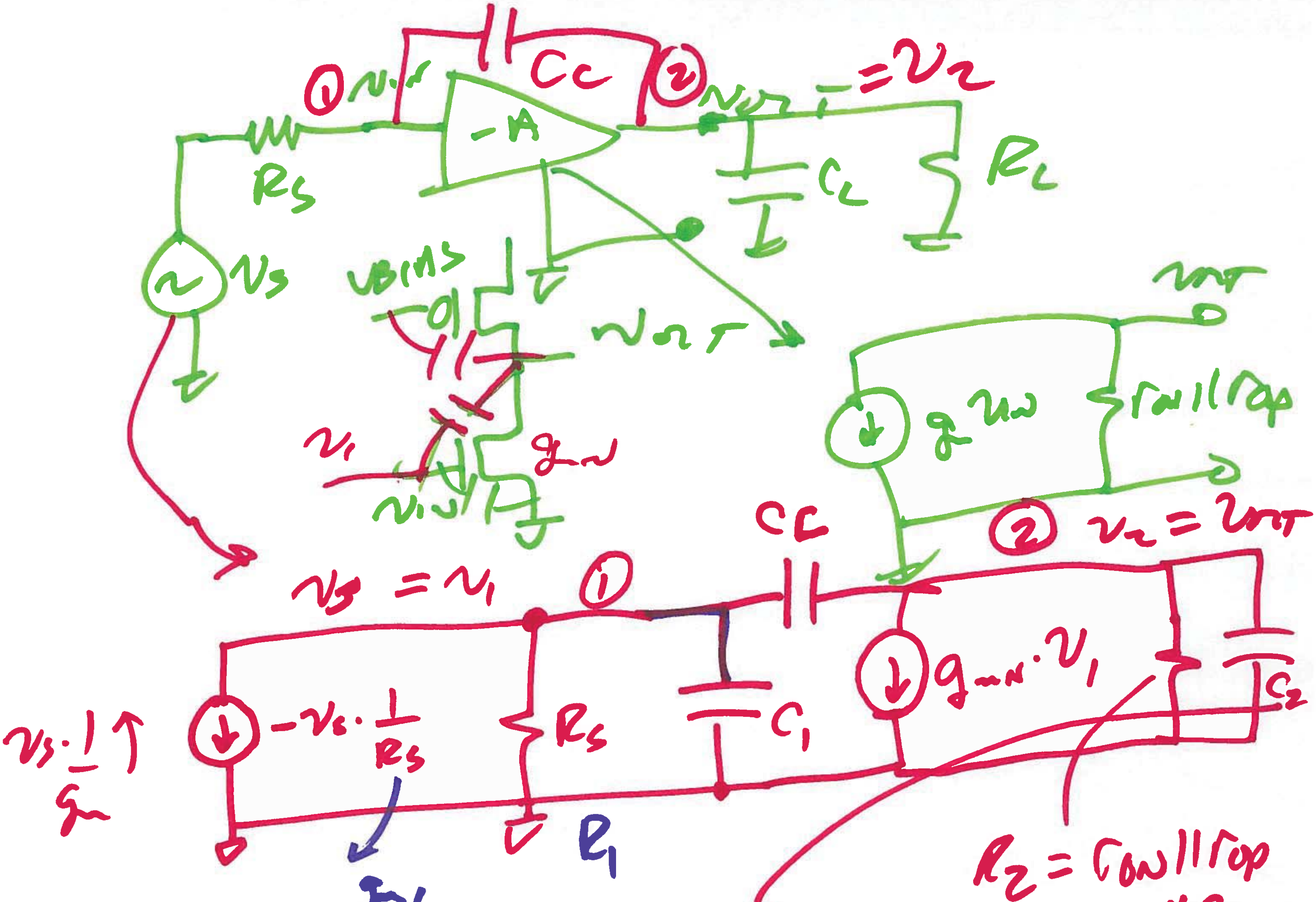
Derive Miller's Theorem

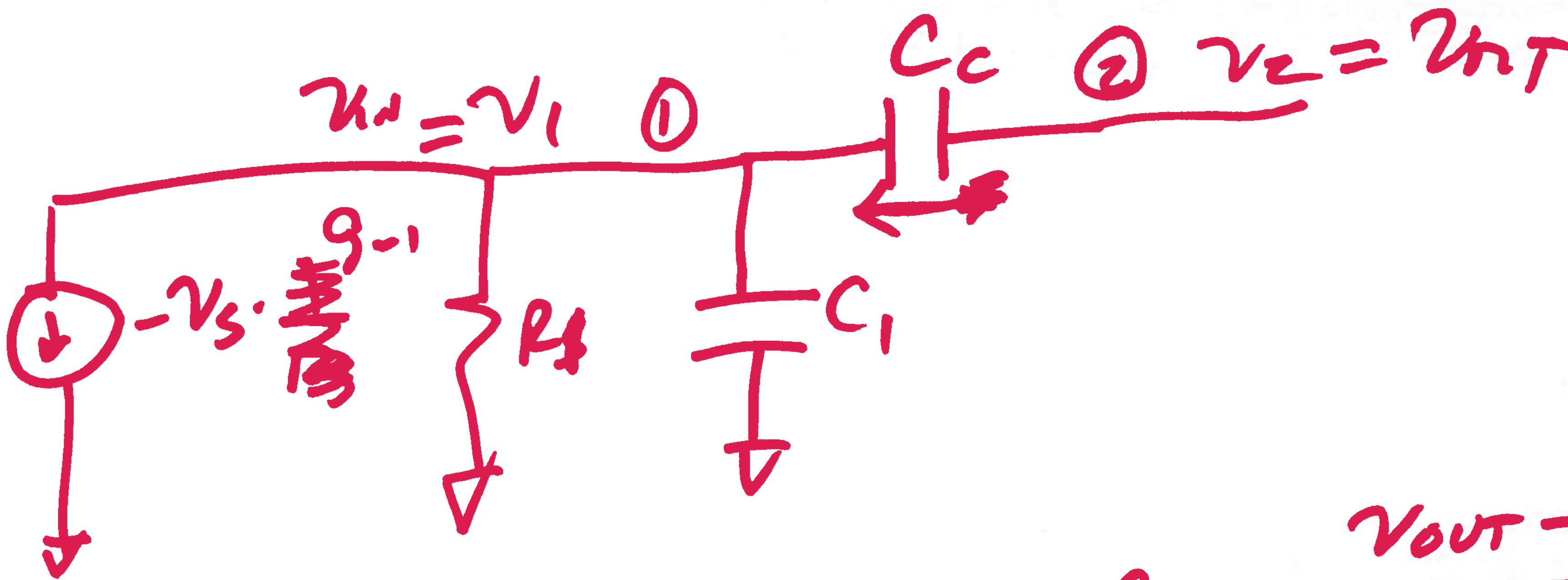
$$i = \frac{v_{in} - (-A \cdot v_{in})}{1/j\omega C} = \frac{v_{in}(1+|A|)}{1/j\omega C}$$

$$v_{in} = i \cdot \frac{1}{j\omega C(1+|A|)} \quad (C_{in})$$

$$i = \frac{v_{out}\left(\frac{1}{|A|}+1\right)}{1/j\omega C} \rightarrow v_{out} = i \cdot \frac{1}{j\omega C\left(1+\frac{1}{|A|}\right)}$$




Cc
-A
Rs
v_s
C_L
R_L
VBIAS
vout
g_{mn}
v_1
$r_{on} \| r_{op}$
CC
$v_s = v_1$
$v_2 = v_{out}$
$-v_s \cdot \frac{1}{R_S}$
$v_s \cdot \frac{1}{g_m}$
Rs
C_1
$g_{mn} \cdot v_1$
C_2
R_1
$R_2 = r_{on} \| r_{op} \| R_L$
$C_L + C_{gdp}$



$$v_{in} \cdot R_1 \,||\, \frac{1}{j\omega C_1} - v_{in} \cdot g_{m1} = \frac{v_{out} - v_{in}}{1/j\omega C_c}$$

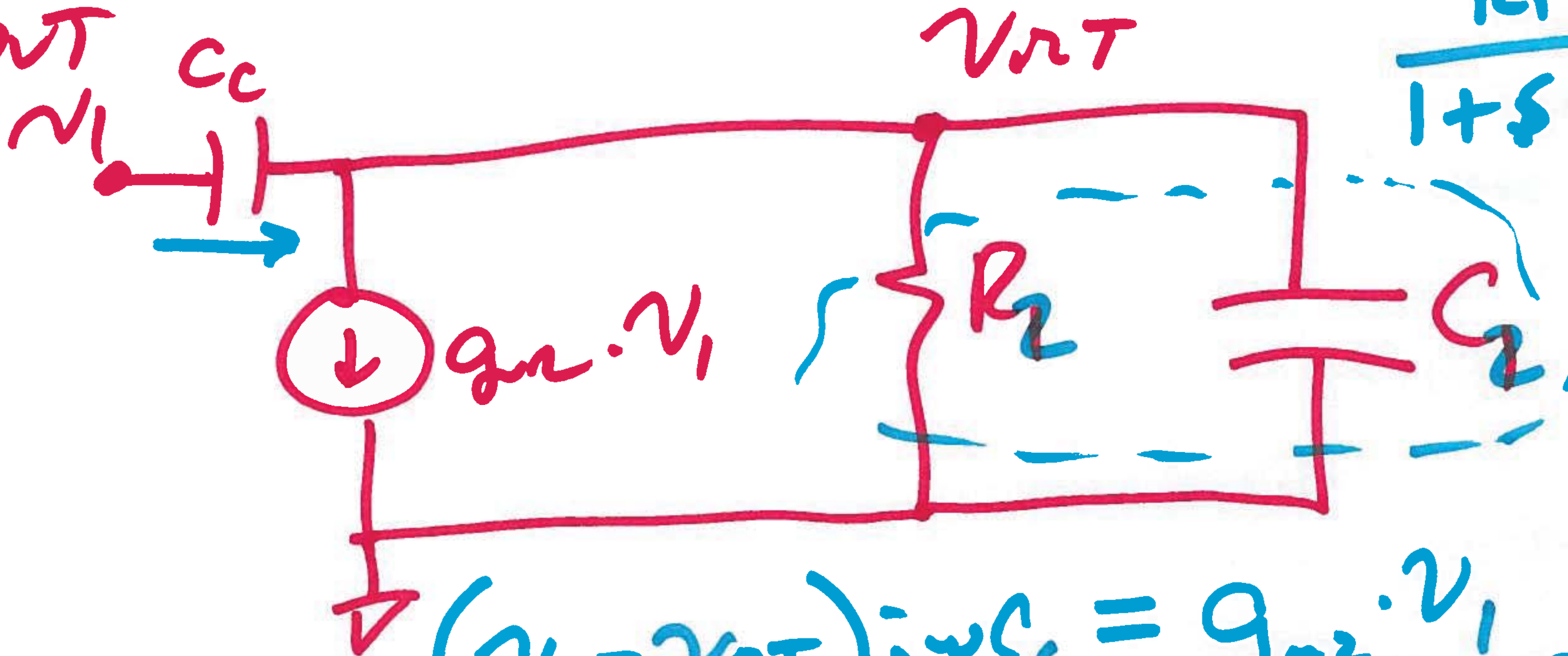
$$v_{in} \cdot \frac{R_1 \cdot \frac{1}{j\omega C_1}}{R_1 + \frac{1}{j\omega C_1}} - v_{in} g_{m1} = j\omega C_c (v_{out} - v_{in})$$

$$v_{in} \cdot \frac{R_1 / j\omega C_c}{1 + j\omega C_1 R_1} - \frac{v_{in} g_{m1}}{j\omega C_c} = v_{out} - v_{in}$$

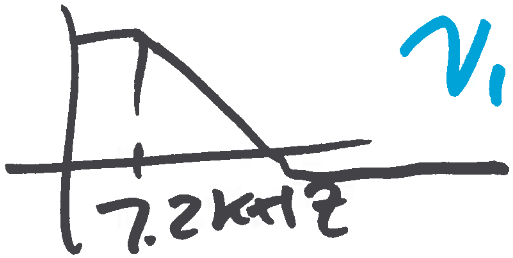
$$v_{in}\left(1 + \frac{R_1}{s^2 C_1 C_c R_1 + sC_c} - \frac{g_m}{sC_c}\right) = v_{out}$$

INPUT

OUTPUT



$$(v_1 - v_{out}) j\omega C_c = g_{m2} \cdot v_1 + v_{out} \Big/ \frac{R_2}{1+sR_2C_2}$$



$$v_1(-g_{m2} + j\omega C_c) = v_{OUT}\left(j\omega C_c + \frac{1+sR_2C_2}{R_2}\right)$$

$$\frac{v_{OUT}}{v_1} = \frac{-(g_{m2} - j\omega C_c)}{j\omega C_c + \frac{1+sR_2C_2}{R_2}} \cdot \frac{R_2}{R_2}$$

$$= -g_{m2}\cdot R_2 \cdot \frac{\left(1 - \frac{j\omega C_c}{g_{m2}}\right)}{1+s(R_2(C_2+C_c))}$$

zero → $f_z = \frac{g_{m2}}{2\pi C_c}$

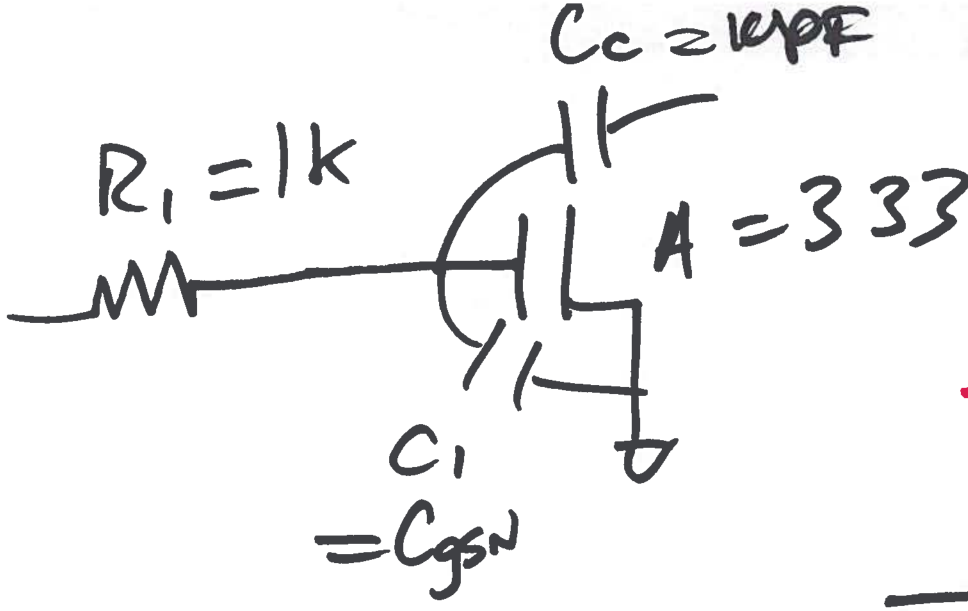
pole ② → f_2

$$f_2 = \frac{1}{2\pi\, r_{on}\|r_{op}\cdot 10\,pF} \approx 7.2k$$

2.2MHz

$$f_z = \frac{g_m}{2\pi C_c} = \frac{1}{2\pi\cdot\frac{1}{g_m}\cdot C_c} \approx 2.4MHz$$

5)



$$f_2 = \frac{1}{2\pi \cdot 6.5k \cdot 30fF} = 8\,[illegible]\ MHz \quad 16$$

$$f_{3dB} = \frac{1}{2\pi \cdot 1k \cdot (23f + 333 \cdot 10pF)} \approx \frac{1}{2\pi \cdot 333 \cdot 10pF \cdot 10^3} = \frac{100\ MHz}{2\pi \cdot 333} = \frac{15.9\ MHz}{333} = 47\ kHz$$

~~47.8 kHz~~

$$47kHz = \frac{15.9\ MHz}{333}$$

$$f_2 = \frac{1}{2\pi \cdot \frac{1}{g_{m2}} \cdot \left(C_1 + \frac{C_1 \cdot C_2}{C_c} + C_2\right)}$$

$C_1 = 23fF$, $C_2 = 6fF$, $\frac{23f \cdot 2f}{15f}$

$\frac{1}{g_{m2}}$: 21.66

6)